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UNDERDRAINING.

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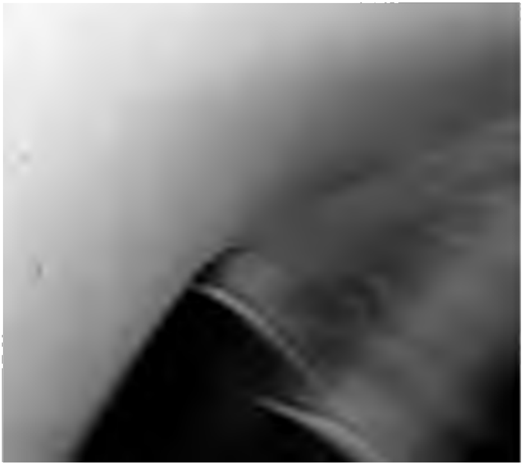

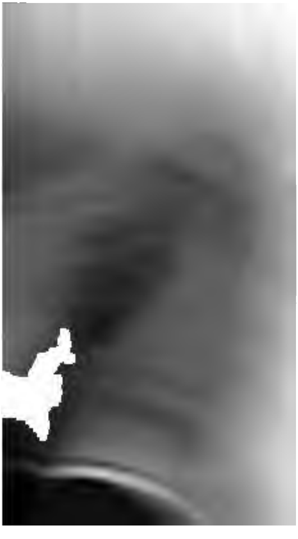

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A PRACTICAL ESSAY

ON

UNDERDRAINING.

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A

PRACTICAL ESSAY

ON

THE MOST ECONOMICAL AND EFFECTUAL MODES OF

UNDERDRAINING.

BY

JOHN WIGGINS, Esq., F.G.S.,
LAND AGENT.

LONDON:
J. & W. NEWMAN, 69, NEW BOND STREET.

M.DCCC.XLVII.

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This Essay is printed chiefly for gratuitous circulation amongst Tenantry, &c.; but a few copies *may be* had at the Publishers in Bond Street, and at Mr. NEWMAN'S, Bookseller, 235, High Holborn.

AN ESSAY,

&c.

A Committee of the House of Lords sat from 28th April to 29th May, 1845, hearing evidence as to the benefits likely to be derived from a legislative enactment, enabling possessors of entailed estates to charge thereon the expense of draining and other improvements. In the course of this inquiry, the best agriculturists and scientific and practical drainers were examined as to their practice, and its results; and the Report and Evidence form the Parliamentary Paper, No. 490, dated 11th July, 1845.

The principal points of their evidence, so far as practical underdraining is concerned, are embodied in the following pages, together with my own experience, and collections from various other authorities, under the heads of—

I. Materials for Underdraining.
II. Depth of Drains.
III. Distance of Drains.
IV. Cost of Drains.
V. Direction of Drains.
VI. Execution of Drains.
VII. Benefits of Draining.
VIII. Best Mode of Draining Estates.

I.

AS TO THE MATERIALS FOR UNDERDRAINING.

The universal conviction of existing necessity for extensive and effectual underdraining in the British Islands, and the general desire, both on the part of landlords and tenants, to perform it, renders the subject most important and interesting to the whole community; and my having been the means of underdraining at least 20,000 acres within the last thirty years, through the medium of tenants whom I encouraged to drain by a fair and liberal allowance of draining tiles, may perhaps justify the present attempt to promote the most economical and beneficial practice of underdraining, especially as I am called upon by professional duty to direct, so far as a land-agent can, the underdraining over several extensive properties now either in the beginning or continuation of that essential improvement, and have therefore compiled this Essay for distribution among the tenantry.

The tiles allowed were mostly arched or horse-shoe tiles, of about 2½ inches opening and 3 inches high, resting on flat tiles or soles, which were placed continuously, so that the joints or joinings of the arched tiles were brought into the middle of the flat tiles or soles. In many cases, the tenants requested larger tiles for mains or watery places. In some places they would (contrary to my opinion) place the arched tiles on apparently solid clay, or other drain bottoms without the soles. But I have invariably found them to repent this, by the gradual sinking and ultimate immersion of the tile into the clay, however stiff it might appear at first; the sole being found to preserve the continuity of the tube, whatever twisting or other changes the tile drain might undergo by reason of contraction and expansion of the earth or otherwise. In the arched tile draining, therefore, the sole is highly important.

In the commencement of the process of underdraining as a substitute for ploughing up the *lands* into high ridges and low furrows, as now found over all the vale lands of the West of England, the Government, in order to encourage this kind of drainage, made an exemption of duty in favour of soles for draining tiles. But they prescribed in the Brick and Tile Duty Act of that day such a description of sole tile, so perforated and scolloped, and of such dimensions, that the use of it was impracticable, since it must have been made by Wedgewood himself to have endured the proposed service.

This I found to be the case, when I had a large estate to underdrain belonging to the late Sir Thomas Hare, Bart., who most judiciously encouraged his tenants to underdrain, by a liberal allowance of tiles and soles, from 1811 to his demise in 1832; and the same encouragement has been ever since extended to them by the present Baronet.

In or about the year 1821, I applied, in the late Sir Thomas Hare's name, to the excellent county member for Norfolk, the Hon. Edward Woodhouse, to obtain an amendment of the Brick and Tile Act in this particular, and a cessation of duty on tiles made and used for the purpose of underdraining,—whether arched, named top tiles—or bottoms, named soles; and by the indefatigable exertions of that gentleman, by means of his representations to, and influence with the Treasury of that period, he obtained, first, circular letters to every exciseman in the kingdom not to charge duty on arched tiles and soles for draining, and then a new Brick and Tile Act, exempting such tiles under easy and reasonable restrictions, merely pointing to their non-use for other purposes. Having attended this gentleman for many days during his arduous task, I cannot refrain from here bearing testimony to the successful assiduity for which all drainers should now feel at least as much gratitude as is usual for past services.

In the course of underdraining many thousand acres of land, chiefly of a sandy surface, with a variable chalky clay subsoil, I tried pipe tiles of 2½ inches bore, making about 100,000 of them one year, as cheaper than the arched tiles and soles; but the tenants requested that no more might be made, alleging that, in their marley clay subsoils, sandgalls occurred, which either filled these pipes, or they sunk in the sand, and destroyed the run of the drain. They were, therefore, discontinued, and several millions of the arched tiles and soles have been since furnished to the tenants, vastly to their benefit, and to that of the estate.

In Essex, however, amongst diluvial (*i. e.* oceanformed) gravelly sands and clays, alternating at short distances, I find the pipe tiles much approved; and where gravel abounds, they are laid on a bed of, and covered with rounded or water-worn stones, and act admirably.

Wood and straw have been for centuries used in Essex, merely to keep the earth of narrow, shallow, and very close drains from closing in; and these have answered the purpose for twelve or fourteen years, but then require to be renewed, and are perhaps in the end more expensive than the drains deemed requisite at the present day. These kinds of drains are not, however, to be altogether discarded, since, when wood is plentiful, when much is to be done quickly, when expense is a present object, and in many other cases, this mode of draining may be very applicable for wingdrains, tiles being used for mains. Of the different kinds of wood applicable to draining, the blackthorn stands pre-eminent; but this may in some measure be owing to the slow growth of that wood, since almost any other wood, when old and solid, is equally lasting in drains; and perhaps all woods will be so in proportion to their age, although scarcely any old and solid woods are so well fitted to fill drains as blackthorn, by reason of its slim, long, and straight growth; and no young wood seems to stand so well as elm of the red, small-leafed or nave variety, of which the smallest twigs are available.

Tiles do not require so much loose covering at top of them as young drainers usually bestow. The water does not, and ought not, in fact, to come into them from above, but from a distance at their sides proportioned to their depth.

Clean or washed gravel is an excellent material for filling drains. Fine clean gravel, forming the beach or shingle of the seashore, is much used in Essex, with the best effect.

The pasture lands in Bedfordshire are most effectually drained with the surface turf, jammed well into a narrow cut, grass side down. Sometimes there is a shoulder to receive this turf, but the jamming is sufficient.

Of the Evidence given before the Committee, mentioned aforegoing, we quote:—

1. Mr. JOSIAH PARKES, Consulting Engineer to the Royal Agricultural Society, who says, that the pipe or cylinder tile of an inch bore forms the best known conduit for the parallel drains in clay soils, but for a run not more than 300 yards.

He approves, in the case of main drains, of having a great length of wings, 2-inch pipes side by side, and one at top. Does not approve of the socket pipe, on account of expense, and being unnecessary; but smaller tiles may be fitted into larger, to form a continuous tube through soft earth; or a short piece may be used as a cover joint; or sods may be rammed in soft bog till the bottom is firm, and the tiles laid thereon. Does not approve of gravel or broken stone, but deems the open conduit by tiles necessary. *Pipe tiles must be laid at the bottom of a trench formed exactly of their own size, so that they cannot stir right or left.* There is much less chance of their being disturbed than the semi-circular tile, and no vermin can get into them. The water enters through the crevices between one tile and another; and if a pint of water enters every hour, or two thimblesful per minute, it will carry off half an inch (fall of rain) in twelve hours. There is no occasion for holes in the pipes: 8000 of these pipes is a fair waggon-load, and they are sufficient for seven or eight acres: they weigh about a pound each, or 14 to 16 ounces per foot. Heath is a good covering for these tiles, but some ram the clay on them with good effect. This, however, should be tried first in each case, although, in the mode of draining, by ramming clay on a mandril, which is drawn forward for a fresh length, the water enters freely at bottom in the stiffest clays.

2. **John Mills**, Esq., of Bisterne. Uses gravel on tile drains with good effect—3 or 4 inches of gravel on, and some around the tile, in a flat country, where gravel is plentiful.

3. Mr. J. **Thompson**, near Reigate, Surrey. After draining with bushes, got crops, increased from 4 to 6 quarters of wheat per acre. Prefers pipes of 1½-inch and 2-inch bore; and now uses them instead of bushes, which are liable to moles and other accidents.

4. Mr. **Putland**, Hurst Green, Salehurst, Sussex. Drains his very stiff, retentive clay with inch-pipe tiles. Answers well.

5. Mr. T. **Spencer**, Wrotham, Kent. Has a very stiff soil, and has drained with pipe tiles for two years. They take the water off very well, and dry the stiff land so as to enable him to grow turnips on it. 1320 tiles will do an acre at 2 rods apart.

6. Mr. **Hewitt Davis**, near Croydon. On a gravelly soil, with a sandy and gravelly subsoil.

Found drains with bushes and chalk worse than nothing. Drains entirely with inch-pipe tiles, and 1¼-inch. The carriage on them, fifteen miles, is worth 5*s.* per 1000. Covers them with heath. Does not approve of gravel. *The pipes should be accurately embedded in the bottom of the drain, so as to be unable to move, or the ends to shift from each other.*

7. Mr. **Robert Neilson**, near Liverpool. Soil, strong loam on a very retentive clay. Generally uses arched tiles, 3 inches by 2½ inches, on soles of slate; but has made some very successful experiments with tiles, 1¾ inches high, and 1½ inches wide, in a strong brick-earth clay, which answered well, and best when deepest; and the tiles covered with puddled clay, so as to be impervious to water.

8. Mr. **John Reed**. In the strong clays of the weald of Kent. Has made and used draining tiles for thirty-five years. At first, made the horse-shoe tile and sole 3 inches wide, and 4 inches deep. Found them larger and more expensive than necessary. Then made pipe tiles of 1½ inches diameter; turned them on a mandril. Afterwards reduced the tiles to 1 inch, which answer perfectly, if well and judici-

ously laid. "The misfortune is not doing it well. They must have a bed cut out with a scoop. If they are put in wedged at the bottom and quite true, it is quite impossible for them to vary. Has seen the water from twenty-three hours of rain carried off in less than twelve hours by inch pipes, in a 3-feet drain."

9. Mr. **Charles North**, of Legburn, near Louth, Lincolnshire. Has drained a various soil; sand, gravel, and clay on chalk. Uses horse-shoe tiles and soles, pipes not being made thereabouts. Places sods of turf over the tiles. Uses also chalk broken for drains. Is beginning to use pipe of 1¾ inches; but as the clay is soft, places a firm sole under them.

10. Mr. **James Smith**, of Deanston, in Scotland. Drains much on various soil of alluvial clay, debris of old red sandstone, and a moorish gravel. Has done much with stones broken to the size usual for roads, and tolerably even-sized. The drain should be 4 inches wide at bottom, and 6 to 8 inches high of stones shovelled in loosely, and covered with a thin turf. Then he recommends very stiff clay to be rammed or trodden down on the turf. Thinks tiles better than stone, when the fall is

great. Approves of inch pipes for lengths of about 200 yards. Prefers tubes of larger dimensions, because they are more fitted to keep their place in the soil.

11. Mr. W. F. Hobbs, near Colchester, Essex. On mixed soil surface, springy gravel beneath, and tenacious clay below. Distinguishes between spring draining and surface draining. For spring drains, uses horse-shoe tiles, from 4 to 6 inches diameter, and some larger. They are necessary, to prevent filling with silt and sand. One drain will often dry many acres. In surface draining, uses pipes in preference to tiles, because more economical, and the circular bottom is preferable to the flat bottom; but does not approve of them if smaller than 2 inches bore. Are apt to choke, if smaller; and the workmen cannot be depended on to lay them with sufficient accuracy to admit of a smaller pipe than 2 inches. Tiles and pipes do not require gravel or loose stones, as the land cracks after being drained, and the water percolates through the fissures, though perhaps the effect is not visible for the first twelve or eighteen months. Thinks a 2-inch pipe likely often to run full, and so be well cleaned out; but recom-

mends "nothing less than a 2-inch pipe," and approves of sockets in some cases.

12. Mr. **Henry Dixon**, of Witham, Essex. On a calcareous loam and clay, with springy gravels. Practises both spring and surface draining. In spring draining, digs holes, which stand nearly full, and generally level. Cuts drains so as to empty all those holes. One skilfully-laid drain dries a large space. When lands are flat, a well is dug at end of the drain, which increases the fall, the well generally standing lower than the drain. For surface draining, makes and uses 2-inch pipes; none less. They are 15 inches long, and cost to make 19*s.* 3*d.* per 1000; coals being 25*s.* per ton. Sells the tiles at 27*s.* per 1000.

13. Mr. **John Pearson**. A professional drainer. Thinks the pipes generally too small. Uses no tiles under 3½ or 4 inches run for spring draining, and 2 inches for surface draining. Has declined using inch pipes. Does not like the socket pipe. Does not want holes in the pipes. Began draining with stones; but found that the surface water got in, and washed the stones full. Prefers the horse-shoe tile, with soles covered with straw or furze.

14. Mr. WILLIAM HUTLEY, of Witham, Essex. On a chalky clay or marle, with a thin skin or staple. In spring draining, for main drains, his tiles are 6 inches by 5 inches, and 12 inches long, costing 90*s*. per 1000. One of his main drains dried forty-eight acres. In this case, a 9-inch main was insufficient at the outfall. The 6 by 5-inch tiles were laid double for the mains, single for the wings. For surface draining uses 2-inch pipes, with a little gravel on the top. Prefers them without sockets; *but is very careful that the bed in which the pipe is placed should be no broader than the width of the pipe itself.*

15. Mr. THOMAS BALMER, Berwickshire. Has drained both with stone and with tile. The stone drains are formed by putting three or four wedge-formed stones upright, about 6 inches high, in the bottom of the drain, close together at top, the narrow edge being downwards; then a covering of loose small stones to within 16 or 20 inches of the surface. The tile drains are preferred, because the work is more easily got well done. Covers the tiles with turf before filling in the earth.

16. PHILLIP PUSEY, Esq. Has just purchased

200,000 inch pipes for draining cold clay land, and finds 2000 pipes per acre sufficient. Is quite sure the inch pipe, laid 3 or 4 feet deep, and the clay rammed over it, will effectually drain the land by reason of fissures or cracks in dry times.

17. **The Earl of Ducie.** Approves of pipe tiles, and, from all the inquiries he has made, is decidedly of opinion that he shall not use any other material in draining.

We have here the practice and opinions of seventeen of the most eminent drainers and agriculturists of the present day, solemnly given on oath before one of the highest tribunals in the country. On a fair revision of that evidence, it may be remarked,—That pipe tiles of 1-inch bore have been found very effectual in clay land drains of 3 to 4 feet deep, *when properly and carefully laid.*—That although 2-inch drains are considered by several witnesses as the minimum size, yet all those witnesses practise draining on lands of various texture, and full of springy—provincially, "squally"—spots and "sandgalls," and where drains are liable to silt up; hence the distinction between spring and surface draining. The necessity, therefore, or the prudence of using

2-inch pipes in such situations by no means impugns the fitness of 1-inch tiles for more uniform and firmer soils.—That it appears that the most experienced drainers have gradually lessened the bore of the tiles they used.—That both science and practice have convinced drainers of the impropriety of carrying off the water too quickly, and so depriving the soil of its beneficial chemical effects.—That in cases of longer run than 300 yards, two or even three inch pipes may be requisite or be used together.—That in cases of somewhat variable soil, it may be prudent to use pipes of 1½ to 2 inches bore.—That in draining across sandgalls or soft unfirm spots, either smaller pipe tiles may be inserted into larger, or, before complete drying in making, the edge of one pipe may be reduced with a knife, and the opening of another somewhat enlarged, so as to produce a continuous tube.—That there is no actual necessity for covering the tiles with anything but the soil dug out of the drain.—That the closer and harder the covering of the tile, the better it will be defended from external injury.—That the drain should not be pervious to the surface water of the land immediately above it.—That the water enters the tiles at the bottom thereof, not by descent from above them.—That other materials for draining than tiles may be effectually used, according to the convenience of parties; such as broken stone, wood, and straw or heath, blackthorn, stone on edge, &c.

We shall now, in treating on the remaining heads of our subject, advert to the important evidence of these witnesses, under the numbers affixed aforegoing to their respective names, and this reference to numbers will include also, not only names, but situation and soil, matters very important to be kept in view.

II.

ON THE DEPTH OF DRAINS.

Having for many years been a strong advocate for drains, not on any account being less than 3 feet deep if the outfall will allow, I hail with great satisfaction the fact of my long-cherished opinions being supported by the highest authorities. My "Directions to Tenantry, 1833," given in Appendix A, and also my Paper in the Journal of the Royal Agricultural Society of 1840, Appendix C, show how such drains become much more efficacious than shallower drains, even in close, heavy, tenacious clays; the water drawing by the attraction of its particles or globules from the lowest to the highest point in a slanting direction, because that direction is the one of easiest descent. Besides, all my experience, in the drainage of many thousands of acres by means of tenants, has led to the conclusion that deep drains are infinitely more efficacious than shallow ones, and that 3 feet is the best standard for general practice, although there are soils and situations where 4 or more feet may be still better, and 30 inches may in other peculiarly tenacious soils be the proper medium.

It is certainly a common fault with drainers of small experience, or such as long habit has confirmed in error, to be impatient of seeing any water stand at any time on or near the surface, without reflecting that through the medium of rain-water many fertilizing properties are imparted to the soil, and if this medium is too much limited in its passage through the soil, and consequently in the time required for its operation, the soil is deprived of great benefits.

Mr. Parkes, the scientific drainer, and Engineer of the Royal Agricultural Society, says that drains ought always to discharge clear water, and it is only deep drains that do this. Shallow drains discharge thick or cloudy water, in which are suspended and carried off the finer and most fertile particles of the soil. The happy medium has therefore been diligently and earnestly sought between a sudden rush of water from the upper surface on the one hand, and too much stagnation at the bottom on the other hand.

Mr. Parkes would, on this account, have no top grips or water furrows on the surface of arable lands, but let all the rain percolate through the soil down to the deep drain, leaving its fertilizing qualities in the soil.

The evidence on the very important point of depth of drains, given before the Lords' Committee, runs as follows:—

No. 1.—Mr. Parkes exhibits a communication from the Hon. Charles Arbuthnot, an eminent improver, stating that he drained strong soiled pasture lands with shallow drains, viz. 26 inches, without effect; that new drains were placed *at* 4 *feet deep*, with pipes 3 inches diameter in the mains, and 1½ inch in the furrows or wings. That at the first rains the deep drains carried all the water quickly off, and have since rendered the land perfectly dry. That Mr. Arbuthnot is convinced inch tiles would have answered the purpose quite as well. Mr. Parkes is asked, "What is the minimum of depth?" and answers, "Land should never be drained to a less depth than 3 feet, and 4 feet is preferable whenever an outfall can be obtained, at which depth it will rarely occur that drains need be placed nearer than 33 feet asunder." In the stiff Lias clay of Glastonbury Vale, 3-feet drains acted well at 60 feet asunder. The pipe tiles are permanent in position *at* 3 *feet deep* or more, but at less length are liable to be increased. Wells or swallow holes, sunk 15 or more feet deep, and 6 feet diameter, will generally afford an increased fall to drains brought into them, the water standing in them lower than the adjoining levels by reason of absorption of the strata penetrated in sinking these wells. Deep drains provide for a head of water at all times sufficient to keep the drains scoured out; for even if the country is flat, and the outfall can only discharge gradually, the water will accumulate at a depth that can do no harm. Even in flat flooded fields, laid with inch pipes, they have not been stopped up. Deep drains work by means of the fissures caused by cracks in the soil consequent on drought in the closest and most tenacious clays. These cracks do not occur in moist clays till after drainage; and then not only large chasms or openings occur in droughts, leaving the masses between solid and entire, but smaller and more numerous fissures also take place, by which the air is made to pervade the interior of the soil, and from the absorption of this air by the soil a certain degree of moisture arises which is highly beneficial to vegetation.

No. 8 states that his drains on clay with sand

and gravel are 36 inches deep, and answer well; but would have made them deeper, had the outfall allowed, it being a flat country. Would have preferred 40 inches.

No. 3 states that he at first drained 30 inches deep, but from great experience has become convinced that deep draining is best as *"to the depth which land-cracks' water will go down."* Makes some drains in clay 6 feet, but commonly 4 or 5 feet in clays that will crack. *"The advantage of going down so deep is that it draws water from a greater distance, and filters it through a greater depth of soil."* Fewer drains will do, if deep. Has made experiments, to convince himself and others. Has made one fleet drain, and one deep drain. Little water is ever seen to come out of the fleet drain, because the land must be saturated with water up to and above the fleet-laid tile before it can run; but the land being cracked to a great depth, the water sinks down through those cracks to the deep-laid tile, and sets it running. The deeper you cut, and the more porous the soil is, the fewer drains you want.

No. 4 commenced draining in the very close stiff clays of the Weald of Sussex at 4, 5, and

6 feet, but found it too deep for the surface water; and came to 2, 2½, and 3 feet with inch tile, at about 30 feet drain from drain. Thinks they will stand fifty years and more. The cost at 3 feet is 3*d.* to 4*d.* per rod digging and putting in the tiles, and filling in the clay by ramming. The drainers expect to earn 2*s.* 3*d.* or 2*s.* 6*d.* per day, with a boy or girl to hand the tiles.

No. 5 began draining stiff clays 20 inches to 2 feet; then got to 3 feet deep; then to 4 feet deep. For the last two years has used pipe tiles in his deep drains, and they answer well. "*The deep drains will always run first and longest, and run most water. The deep drains were running, and the shallow drains were dry. Has drained all his land over again that was drained shallow, and is certain it will produce one-third more corn with deep drains than with shallow drains.*" His 4-feet drains cost 10*d.* per rod, and are 2 to 4 rods apart; the latter distance being much more effectual with 4-feet drains than the smaller distance if shallower. In deep draining, some people say the water cannot get through the clay; but fifteen years' experience has proved to him that a 4-feet drain will run better than a 2-feet drain in the strongest clay, if you put them alternately.

No. 6 says that two great errors are committed in draining. One is, the farmers have an impression that in stiff soils they ought not to put their drains deep,—"that is a sad error;" and then they put them much nearer than they need. By drawing water down 4 feet, the soil becomes warmer in the spring of the year, and you have an earlier and a better growth; and in shallow drains this benefit is lost, besides the derangement by various means of drains so near the surface as 30 inches. He recommends 4 feet as the shallowest depth in clays, and in light soils much deeper. He places inch pipes in all his drains. In a clay soil in Yorkshire advised, professionally, to put drains 4 feet deep, and 50 feet apart, using pipe tiles.

No. 7 made experiments as to the effect of deep and shallow drains, and found that the deepest drains ran the fastest, and entirely dried the shallow drains on each side of them. Two drains, 26 inches deep in loam and clay, were perfectly dry during and after a heavy rain for two hours and a half, whilst a 4-feet drain at 6 yards' distance between them in clay filled a pint measure in four minutes. Five drains were observed daily from 27th March to 26th April;

they were of depths varying from 26 inches to 4 feet. The 3 and 4-feet drains were invariably the most effectual. The 26-inch drains were often dry, but seldom more than dropping, scarcely running at any time, and then becoming dry again; whilst the deep drains filled a pint in from one to four or five minutes, according to weather.

No. 8 began draining at 2 feet, "but found that that was wrong." The manure and alluvial soil was carried off. Has observed a 3-feet drain carry off the water of twenty-three hours' rain in eleven hours and a half. Twelve hours of wet does no hurt to land, but brings manure with it.

No. 9 has drained shallow with thorns at 8 yards, and crossed these with deeper drains at 20 yards. "The deeper the drains, the wider I should have them apart." The water from shallow drains comes out muddy. Deep drains wide apart are better than shallow drains that are close.

No. 10. Mr. Smith of Deanston drains at 30 inches to 36 inches deep, "never less than 30 inches;" and his usual distance is 18 to 25 feet apart. A 4-feet drain is better than a 3-feet drain, but would not consent to widen the distance for increase of depth. The deepest drain will run first.

No. 11. For springs goes from 6 to 9 feet, or if the spring is shallow 30 inches to 3 feet, and 5 to 8 yards apart. At 30 inches the water from drains is often cloudy, and carries off a portion of the finer properties of the soil. At 3 feet the water discharged is clear.

No. 12 digs for spring draining as deep as the springs require, *i. e.* from 5 to 10 and 12 feet, and even 15 feet. One drain often cures many acres, when the water can be taken from a gravel bank or shoal. Surface drains 3 feet deep, and 40 feet apart. "The deeper you make the surface drains the better." At 3 feet, or beyond that depth, the water finds its way into the drain sooner, and runs later than when the pipes are shallower. Three feet should be the shallowest drains, making them deeper if you can, except in strong clay land.

No. 13 deems mixed soil land to require the deepest drains. In the Essex mode goes 18 to 20 and 24 inches deep.

No. 14. For spring draining goes 5 to 9 feet. One drain, of 1432 yards long, dried 48 acres.

Surface drains, 30 inches deep, 25 feet distance. Labour cost 4*d.* per score rods.

No. 15 makes stone drains 30 inches to 3 feet deep, and tile drains 24 to 30 inches; but has cut many drains 3 to 4 feet, and upon boggy moss land 7 feet deep. Deems the deep-drain system a new theory. Has not made up his mind on it.

No. 16. Mr. Pusey says, "One discovery that has been made is, that by deepening the drain below the old English depth in the Eastern counties, which was 30 inches, you may very much diminish the frequency of the drains." He drains some of the coldest and stiffest clays in England with inch pipes 3 to 4-feet deep, and puts the clay at top of them. At first, thought this wrong; but experience shows that at 34 inches deep inch-pipe tile-drains, 30 feet apart, dry the stiff clay effectually, though at first 10 feet distance was thought too great. Was first convinced by observing the fissures in a clay-pit going down above 4 feet. In a wet summer next after draining, these fissures may close, but drought will open them, and they remain open, and the draining prevents their collapsing again.

We may sum up this evidence as to deep-draining by remarking that its advocates rely on,—

1st. Its safety to the materials used in draining, in preventing their disturbance by vermin and tread of horses and cattle, and their displacement by contraction and expansion of the soil in alternate dry and wet weather.

2nd. Its drawing the water from a greater distance than shallow drains.

3rd. Its consequently requiring fewer drains.

4th. Its allowing the rain-water to percolate through a greater body of the soil, and so imparting its chemical contents thereto.

5th. Its filtrating the water so as to prevent the finer particles of soil going off in the water discharged.

6th. Its lowering the water surface sufficiently to prevent stagnation in the subsoil, which is almost as injurious in chilling the surface as the surface water itself.

7th. Its carrying off the water even from stiff clays sufficiently early to prevent injury to vegetation, whilst all the benefits from rain intended and bestowed by nature are retained.

Against shallow drains it is objected,—

1st. That they are unsafe in position, and liable to displacement from many causes.

2nd. That they only take off the surface water, leaving the subsoil saturated, cold, and chilling to vegetation.

3rd. That they thus become little better than a very expensive kind of top gripping, called also water furrowing.

4th. That they can only run off the first sudden downfall of rain, and that before it can have imparted its chemical properties to the soil.

5th. That they carry off much of the finer particles of the soil, and so reduce its fertility.

6th. That they fail to answer most of the important objects of draining, especially that of curing or preventing super-saturation with stagnant water in the subsoil.

7th. That they are unnecessarily expensive, because requiring to be very frequent. The shallow Essex drains, with wood and straw, are cut at every 10 or 12 feet.

Mr. Pusey speaks of the benefits of deep draining as "a discovery made by scientific men, and proved by practical men," with all that care and cautious research and observation which distinguishes the present period. Therefore not to adopt practices recommended on such high authority would be to deprive ourselves of great benefits, and to incur greater expenses with less profit than we might enjoy.

The theory of deep draining in clays rests mainly on the fact of their cracking so as to form channels for the water; but there are also channels formed by minute roots of plants, which penetrate the soil to a great depth, their decay leaving apertures and tubes through which water percolates freely. The borings of worms also form pipes, through which water freely percolates for several feet in depth.

After all, the depth of drains must be greatly influenced by the depth of outfall, which in flat lands is often difficult to obtain sufficiently. Therefore the first object for a drainer is to get his outfall as low as possible with reference to his system of drainage. The next is to give the mouths of his drains a drip of 3 to 6 inches to the bottom of the outfall ditch. Great attention should then be given to keep open the outfall ditches by scouring them out frequently. For want of this attention, great losses are sustained.

I have known, and still know, large farms, in which hundreds of thousands of tiles have been laid, lose all the benefits of drainage by the scouring of the ditches being neglected; all the drains being thus stopped at their outlets. Therefore, to guard against this, all the drains should fall into a main drain, independent of any open ditch; and then the principal outlet will either force itself open, or will be easily opened with the spade.

III.

ON THE DISTANCE OF DRAINS.

THIS head of our discourse has been already somewhat anticipated in treating on the depth of drains, the one being much dependent on the other. The general opinion of experienced drainers, as given aforegoing, seems decided as to the drains being safely placed at greater distances in proportion to their depth. The mode of expression in use among farmers is, that they will *draw* further when deep than when shallow; and therefore the saving is great when you can place your drains with equally good, if not better effect, at 40 feet apart, instead of 10 or 12 feet.

Those who are anxious to receive the benefit of drainage over as large an extent, and as soon as possible, will ascertain pretty nearly the distance to which their deep main drains will draw; and they will place their wing drains at first at double the distance at which they will draw quickly. They will then in due time return to the same ground, and put in another drain between each of the wings, thus completing the drainage. I well remember that, on the very extensive estate in Norfolk mentioned aforegoing, the drains were placed at first at 20 and 30 yards apart. The summer of 1816 was wet; and the young barley crops were perfectly yellow and failing in the middle space between the drains and beyond their influence, but excellent within their draught. Next winter, the tenants were clamorous for tiles; twenty-two waggons came to the kiln-yard the moment the first kiln was burnt off, and the regulations were established which are given in Appendix B; and new drains were placed between the former ones, reducing the distance between drain and drain to 15 yards, which answered well on light lands, but required still again doubling in tenacious soils, bringing them to 7½ yards or 22½ feet distant for 30 inches and 3 feet drains; but in cases where the original drains were cut at 20 yards, once doubling was sufficient, and the land was well drained at 10 yards apart.

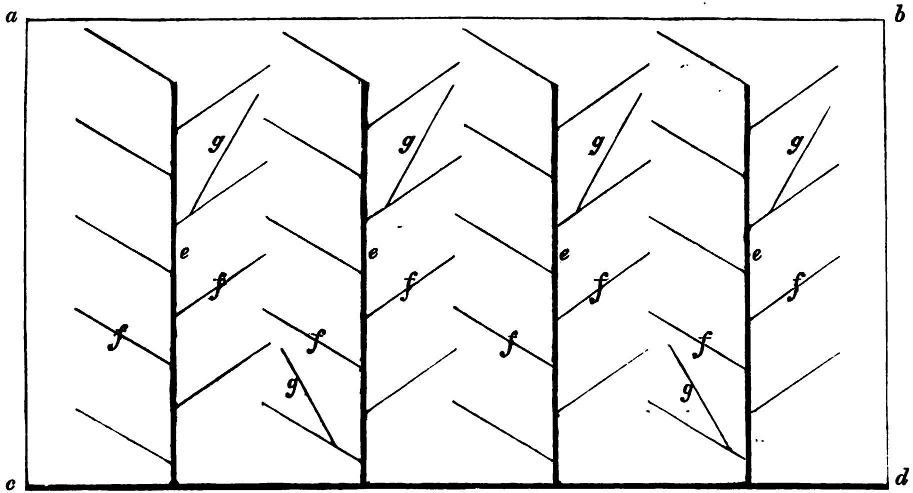
The proper distance of drains in any given soil must therefore depend on the depth of the drains, the tenacity of the soil, and the state of the land; for grass lands do not require draining so close as arable lands; nor do side-hill lands, with a good fall, require to be so closely drained as flat lands.

One point affecting this question seems to have been much overlooked, viz.—that ardent drainers view a wet field as it is, and drain as for its extreme state of wetness; but surely they ought to reflect, that after a moderate quantity of drains have been placed judiciously over the surface at proper depths, a wet field will approximate at least to the state of a dry field, and that, if it still requires a few additional drains in places, it need not be closely drained as if the full quantity of water at first discharged would always have to be discharged. A pond may require a 3-feet tunnel to empty it in a given time, but a 3-inch pipe may suffice to prevent its filling again.

The distance of drains is, however, not always a matter of choice, because in those districts where the soil has been ploughed up into high lands, or ridges of irregular breadth with deep furrows, the drains are necessarily placed in those furrows, which are often ploughed down after drainage to nearly a flat surface—a process which requires to be gradually accomplished, and is best done by raising a small ridge over the furrow, and gradually enlarging that ridge at the expense of the original one.

But although no absolute rules for the distance of drains can be laid down in lands, the surface of which is reducible to several *planes,* I am an advocate for rather distant drains at first, fixing that distance according to circumstances. Thus, for instance, I am now draining several hundred acres of recently-grubbed woodland. I place my main drains at 4 chains, and my wing drains at 2 chains distant, admitting, if still wet, of others winging into them at different times, and dividing the expense into different periods.

The subjoined diagram will elucidate what is meant.



a, b, c, d is a field or space of 18 acres; *e, e* are main drains, 4 chains apart; *f, f, f, f,* wing drains, 2 chains apart, to be increased as requisite, as shown at *g, g*. The outfall is at *c*; the line *cd* being an open fence dyke.

IV.

ON THE COST OF DRAINS.

We have heard much of *thorough* draining of late,—a term at first mistaken for *furrow* draining, the furrows in the ploughed fields in the Eastern counties being provincially termed "*thorows.*" This thorough draining is said to cost,—

	£.	s.	d.		£.	s.	d.	
By Evidence No. 1	2	5	0	to	3	0	0	per acre.
No. 2	4	10	0	„	8	0	0	„
No. 3	2	5	0	„	4	0	0	„
No. 5	2	9	10	„	3	7	0	„
No. 6	2	0	0	„	3	0	0	„
No. 7	4	0	0	„	6	0	0	„
No. 9	3	0	0	„	6	0	0	„
No. 10	6	0	0	„	6	0	0	„
No. 14	3	5	0	„	3	14	0	„
Averages	£3	6	1	„	4	15	8	„

The numbers omitted do not speak to cost. Those quoted average 66*s.* 1*d.*, the minimum; coming up to 95*s.* 8*d.*, for the maximum cost on average, three instances being £6, and one £8 per acre. But John Bowes, Esq., a witness, drained 538 acres at an actual cost of £4. 6*s.* 8*d.* per acre.

The mode of draining particularized aforegoing would be an economical and yet effectual one, if the line *cd* in the diagram was an open fence ditch, and the mains only were laid with tile, and the wings with wood, there would be only four main drains, each of 10 chains long, to a field of 18 acres = 40 chains, requiring about 2000 pipe tiles of 15 inches long. The wing drains at 2 chains apart would be 80 chains; and if each had a wing, as at *g* in diagram, it would *thorough* drain the piece of land. But only particular spots will require this, especially if it be pasture land. Take therefore such wings at half the extent of the original series, and we have, besides the 40 chains of main, 120 chains of wing drains, dug 30 to 36 inches deep, and filled with wood and straw; the cost of which will be as undermentioned,—

	£.	s.	d.
2000 draining tiles at 20*s*. per 1000	2	0	0
40 chains main drain, dug, laid with tiles, and filled, at 2*s*. per chain	4	0	0
80 chains = 320 rods wing drain, dug and filled, at 3*d*. per rod	4	0	0
40 chains = 160 rods ditto, as wanted	2	0	0
2 loads of wood. (In Essex they use half a load to 120 rods)	1	0	0
4 loads of straw (1 load to 120 rods)	4	0	0
Carriage and sundries	1	0	0
Total. .	£18	0	0

viz. exactly 20*s*. per acre. But the wood ought scarcely to be reckoned, being the produce of the estate; and in all cases where the surface admits of turf, or the neighbouring woodlands or commons of sedge or heath, instead of straw to cover the wood, most of that expense may be saved, or greatly mitigated, by using haulm or stubble, or the brambles and coarse outruns from hedges, or even furze, rushes, reeds, hedge greens, or other worthless substances. Nay, a little ingenuity and a little labour would construct a roofing of rammed clay over the wood, that should secure it effectually from the soil falling in. And really where much is to be done, economy is a most essential quality to study in effecting it. Even the manufacture of tiles, we think, may still be much economized by machine—making them in or near the field, drying under moveable sheds covered with the light, portable felt, and burning them in clamps protected from the wind by the shed roofs. Even in established kiln-yards, an improvement strikes us in the mode of drying, which we think might be accomplished on shelves around the kiln, so as to render available the heat at present lost in the earth embankment usually made about its sides.

It is fair to state, that if the whole was done with tiles, the cost of the eighteen acres would be as under, subject, however, to reduction in the price of pipe tiles, which Mr. Parkes states so low as 6*s*. per 1000:—

	£.	*s.*	*d.*
7700 draining tiles, at 20*s*. per 1000 . . .	7	14	0
160 chains, cut and filled, at 2*s*. per chain . . .	16	0	0
Carriage and sundries	1	6	0
	£25	0	0

or about 27*s*. 6*d*. per acre; and the difference of 7*s*. 6*d*. per acre in expense is not so great as to make it worth while to use wood and straw, unless those materials are convenient; besides, *every* use of straw, except in making manure, is objectionable.

V.

ON THE DIRECTION OF DRAINS.

The direction in which drains are to be cut, with respect to the surface of the land they are to drain, is a point of considerable importance, and has occasioned much diversity of opinion,—some contending that they ought to run straight up and down the side hill to be drained, however steep; and others, that they should have a diagonal direction. We confess ourselves to belong to the latter class, although aware that the recent general practice is the other way; and that such controversies, like that of the little endians and big endians in breaking an egg, would be mischievous if the discussion suspended the operation of draining until the point was settled to universal satisfaction.

We hold, however, on this point,—

1st. That to drain up and down a steep hill gives the drain too quick a run, and is apt thereby to silt up its orifice by the accumulation of little shoals of sand. This is particularly the case with stone drains which consist of a congeries of small orifices, any one of which is more easily stopped by the aggregation of particles of sand than the larger aperture of a tile drain. There are few clays so tenacious as not to contain a considerable proportion of sand, and to part with these silicious particles freely under the action of water, so that in a rapid run they lodge one by one against the materials of the drain, accumulate there, and at last choke the drain; whereupon the upper waters coming down the drain over-ride it at the spot obstructed, and burst out upon the surface of the land: so that I have myself stood wet-shod over a drain, whilst a sort of lecture was going on upon its excellence.

2nd. The water is carried off too fast by a steep drain, because it cuts away at its bottom and sides, and becomes a glen hollow at bottom, and so irregular in its form that the materials of the drain, whether stone or tile, are displaced and deranged, and the whole structure falls into confusion, and becomes rather mischievous than beneficial, ending in outruns and shoals of sand, and wet spreading over the surface of its lower levels, and depriving some of the upper parts of the field of valuable materials.

3rd. The drain which is cut up and down the hill must run parallel to the line of direction which the water in the soil has a tendency to take; therefore the line of such drain is not calculated to intercept such water in its passage to the lower part of the hill: but such water may, for aught that appears to the contrary, run close to the side of such drain without ever entering it, because the tendency of both is straight down the hill. (See Section 3, in Appendix A.)

4th. And even supposing that none of these ill effects happen, or that they are not apparent for a considerable length of time after the drain is made, yet such a steep drain hurries off the water before it has had time to render those chemical services to the soil which modern science has developed. If it acts at all, every fertilizing shower is carried away instantly; if not, it is merely a vehicle for a partial and injurious irrigation.

Such are the leading objections to steep drains. It is, however, said in their behalf, that they cut through the outcrop edges of every variety of strata in their line, and so bleed the same, *i. e.* let out the water therefrom.

But it is difficult to conceive any such great diversity of strata cropping out in the line of a single drain as can make this effect valuable, even if it held good in any degree beyond a similar effect in a diagonal drain across the same field.

On the other hand, it is contended that drains should be cut diagonally, and with an easy descent,—

1st. Because such drains intercept the water in its passage to the lower levels, and *catch* as well as *carry* it.

2nd. Because they carry off the water without any rush sufficient to cause any degree of abrasion, and are therefore more safe and permanent than steep drains.

3rd. They discharge the water gently, giving time for its chemical benefits to the soil, yet in time to prevent injury to vegetation.

4th. They run clear water without carrying off the finer particles of the soil, like the steeper drains.

On the subject of declivity or fall for drains,—

No. 1. Mr. Parkes is asked whether, as a general principle, he would conduct the drains diagonally across or straight down? His answer goes to the effect that the straight up and down line is the ancient practice, but that one must vary according to the form of the surface. He would have the water not carried off too rapidly.

No. 2 wishes for a fall of from 1 in 80 to 1 in 120.

No. 6 says, "I have invariably found that all drainage should be up and down the fall, be it little or much. If water runs sidling down a drain, sooner or later it is sure to stop."

No. 7 is doubtful what fall is requisite, but thinks very little fall is required for tile draining; and that stone drains should have a decided fall. His main drains all discharge at one orifice, and have wings into them at right angles. Some mains receive above 40 wings.

No. 9, being asked "What fall do you consider necessary for good draining?" answers, "I think the less the better, as long as there *is* a fall. If there is a sudden descent, it generally silts up, and blows out at the top."

No. 10. Mr. Smith of Deanston prefers stone in steep land, and tiles where there is not much fall. Does not think a considerable fall of much importance. You can drain flat land as thoroughly as land upon an inclination. Would consider a very strong inclination on the side of a hill rather a disadvantage. There is a risk in a sandy bottom of the water coming with too much force, and, cutting the bottom, running under the tiles.

No. 11 cuts up and down the hill for surface draining, upon the principle recommended by Mr. Smith of Deanston. Requires some slight fall, which he determines by a spirit level.

No. 13 thinks about 4 inches in 20 yards sufficient. Has drained at 1 inch in 20 yards.

No. 15 says, "The old system was to cut a drain along the edge of the hill to catch the springs; but of late years the general system is to drain up the furrows. I am thoroughly satisfied now of that being the right system; but it was some time before I was converted to it."

These testimonies are somewhat conflicting; but it may be accounted for in some degree by a kind of fashion that has been lately prevalent, but the adoption of which fashion is, I think, going out; and the steep drains will be chiefly adopted in up and down furrows where high ridges prevail, for there the lines are predetermined, and such lines have for ages been the course of drainage waters.

Mr. Parkes' reply, however, puts the point on a right footing, since you cannot always avoid a steep main drain; but it should always be made as short as possible, with flatter wing drains in the herring-bone fashion, as shown in the diagram aforegoing; and if very steep, the main should discharge into an open ditch, from which the silt should be often cleared.

Now, in such an arrangement as the above, almost all the objections against steep drains would be obviated, because it is in fact the wings that drain the land, the main only discharging what they bring to it gradually, and not in sufficient rush to cause abrasion of the sides or bottom of the main drain.

It may be proper to mention that one witness objects to angles in any drain, and there are many persons who prefer every drain being single and unconnected with others, in the herring-bone fashion. But when it is considered that the herring-bone mode has been practised in the whole county of Essex for above 200 years, and that it has answered so well as never to have been laid aside, we may allow some merit to that plan for other districts, where the surface of the land to be drained is resolvable into a series of inclined planes or facets, each of which may be drained by a series of mains and wings, according to the diagram aforegoing.

VI.

ON THE EXECUTION OF UNDER-DRAINS.

In the course of the observations aforegoing, we have often had occasion to remark on the great importance of the work of underdraining being well executed. In fact, badly-executed underdrains are worse than none, since their failure causes more injurious effects of water upon the soil than their absence. Nothing, therefore, can be more important on the subject of draining than the accurate, efficient, and permanent execution of the drains. Without the strictest attention on the part of the manager, bad work will be buried; and the soil, the depth, the direction, the material, or anything, will be blamed but the execution of the work, to which the want of expected efficacy is most likely due.

We do not, however, here profess to give a complete manual for the performance of the work requisite to the construction of a good underdrain, but only to offer one or two hints, by the adoption of which in practice something may be performed more nearly approaching to perfection than if such hints were disregarded. These are,—

1st. As to the setting out of drains. To lock-spit the lines, and to level the upper surface by means of a gardener's line, and, if necessary, of a spirit level. In such levelling, cutting down the upper surface to the depth at which the tools will work in going the depth intended for the drain; or in other words, enabling the workman to know exactly where the bottom of his drain should be, by measuring with his tools its depth from the levelled surface of the land. This is important, as it prevents the fatal error of digging to the same depth, whatever may be the undulations of the surface, and so having the bottom of the drain undulating also. It is true that such an error to the full extent of making the bottom of the drain parallel with the uneven surface of the land can hardly be conceived, but still small undulations of surface can hardly be expected to be regarded by a labourer intent on earning his daily bread—even if he perceives them, the chances being that they escape his notice, unless very striking irregularities of surface present themselves; and then his observation of them will naturally arise from his having less earth to excavate in the dips, or more in the rises of the surface. Therefore, without the previous process of levelling the top, the bottom may undulate to a certain extent, and any and every the smallest approach to such undulation or irregularity of surface in the bottom of a drain is an imperfection only to be got over by a great fall and a copious discharge of water from the drain; still, however, at last leaving a rise bank or shoal here and there, which stopping the last run of the drain very materially impairs its efficiency, or even renders it injurious.

2nd. In tile draining the drains should be dug a little time, say a few weeks, before filling. This enables the truth of the fall to be seen; and when rain falls, it should go off freely, without standing in places. It also brings the water into the drain from each side; gives it a habit of going there; and thus promotes the free action of the drain when filled. In stiff clay lands, it may be very desirable to keep open the drains during a drought, so that the clay may crack, and the winter water percolate through its fissures.

3rd. Underdrains are often opened to an unnecessary width, and wood drains cannot be too narrow at bottom. In opening the wood drains of Essex, the common plough is used to turn aside at least 9 inches of the depth required; and they are afterwards excavated, first with a common rather narrow spade, then a long very narrow spade, and then cleaned out with a narrow scoop-hoe by a labourer standing astride across the drain at top. In tile draining the drains may be cut very narrow for pipes, because they can be laid without the workman standing at the bottom. But for arched tiles the drain must be wide enough for the workman to stand in it, for the purpose of laying the tile. But even in this case it is very desirable not to have a greater width of drain than is absolutely necessary; and it would be a good plan, after providing width enough for the workman, to cut a bed for the sole and tile, so that their sides may be supported by the solid earth, and so kept more firmly in their places. In laying pipe tiles, this bed must necessarily be provided for them by means of the scoop or fluted hoe used by the Essex drainers.

For stone-filled drains, the width is often greatly exaggerated beyond what is needful. At several inches of width at bottom, several broken stones lie, and get embedded in the mud, choking up the drain to that depth. The water has then to rise amongst the interstices of the upper broken stones, and so go off; whereas if the bottom of a drain to be filled with stones was to be dug very narrow and cleaned with the scoop-hoe, a stone might be jammed in between the sides, so as to leave an aperture or arch below, which would continue for a long time, and would only be obliterated by the jammed stone falling down, when the water would percolate around, acting, in fact, like the jammed grass sod so successful in the grass lands of Bedfordshire.

4th. The manner of laying a drain with arched tiles and soles requires much skill and attention. By some they are laid with the flat tile upwards, because, perhaps, the rounded is preferred to the flat bottom for a drain. But this cannot form so firm a support for the superincumbent earth, or so perfectly continuous a tube as the other way. After much experience we have, therefore, come to the conclusion that the workman should commence laying the arched tiles at the outfall. That, having a boy or girl to hand him the tiles, he should stand on the tiles which he has just laid, and lay the tiles forward and *up* the drain; and the flat tiles or soles should by all means be laid close, not confined to the ends of the arched, because they then form a continuous tube, which will continue entire even if it should twist by the contraction and expansion of the soil. That he should break the joints of the soles with the arched tiles, by causing the middle of each arched tile to come over the joinings of the soles. He should also see that the water coming down the drain (or if none, then some poured in on purpose) goes down the drain behind him. By this process the workman will avoid treading up and poaching the bottom of the drain, and so rendering it an unfit bed for the tiles. The workman standing on the tiles will be a good test of their ability to bear the weight of earth about to be filled in upon them; and also that the softened earthy bottom is firm enough to bear them without sinking, and is likely to continue so with wet.

In laying pipe tiles, a little ingenuity will lead to the adoption of some implement adapted to their adjustment end to end, at 3 or 4 feet depth from the surface; and where long straight blackthorn bushes are used, a stick, forked at the end, is an obvious mode of pressing them down, and bringing them straight in their places.

In laying elm or other wood in Essex drains, the butts of one layer are brought to overlap the spray of the former layer, and so a tolerably equal admixture of small and larger wood takes place.

5th. The providing of proper tools for draining is a matter of much consequence, and can hardly be safely left to the workmen casually employed. The narrow spade and the scoop-hoe of Essex are very useful implements, and especially adapted for pipe draining, stone draining, and wood draining. They are figured in page 558 of part ii. of the fifth volume of Journal of the Royal Agricultural Society, 1845.

6th. As to those implements which have been contrived for the purpose of hollowing out the soil for drainage by a summary operation, Sir C. M. Burrell, Bart., in his evidence before the Lords' Committee, so largely referred to in these pages, speaks with high encomiums of Pearson's draining plough for clay lands *free from stones*, which excavates drains 24 inches deep at three cuts, draining into mains of 30 inches; the effect being to grow an average of 7 or 8 sacks of wheat per acre, instead of 5 as before.

The mole plough is also only adapted to soils perfectly free from stones or sandgalls, and of very even texture. But the horse-power required for these implements is so great that much treading and poaching of the land must ensue. This has been attempted to be obviated by working the mole plough by a windlass. This, however, by the constant change of the distance of the fulcrum from the share, pulls upwards, and so continually decreases the depth of drain, and in a long reach gives several lines for the same drain, some portions of which must be deeper than the rest, and so the drain is only equal to the shallowest part, and injurious to the deepest.

VII.

ON THE BENEFITS OF DRAINING.

Underdraining holds the foremost place as one of the means of improving land by increasing its produce, and consequently its rental value; thus enriching the occupier in possession, and the owner in reversion, whilst the community is benefited by an increased supply of food. Combined with the other ordinary objects of judicious improvement, such as farm-buildings, fencing, marling, &c., practised steadily for many years upon a large estate, I have been instrumental in producing results exceeding £5000. per annum advance of rental value, at an extra expense beyond what *must* necessarily have been borne below an average of £1000 a year during thirty years; or, in other words, property worth £150,000. has been created by means of the expenditure of £30,000. by easy annual instalments. In this effect draining was the most prominent feature of improvement. But this was only the result to the landlord. The result to the tenantry was to change them from a poor supine set of occupiers to an opulent, skilful, and enterprising Society of Agriculturists, improving their farms as much from choice, habit, and a sense of advantages, as from the obligations contracted by the covenants of their leases. To such men every successive hiring of their farms has been cheaper than the last, notwithstanding the considerable advances of each hiring upon former rents, because the great increase of produce gave them greater profits. Nor should the benefits to the labouring classes of the district be forgotten, since the progress of such improvements has afforded them employment which the increased produce has continued.

This statement, though strictly true, is general. We are enabled to give a more particularized account of another instance, which is extracted from the author's evidence before the Landlord and Tenant Commissioners for Ireland, 17th June, 1844. In this evidence, explanations are gone into as to the arrangements made for improving 2714 acres of miserably-neglected cold clay land in the counties of Northampton and Huntingdon; the terms of agreement with the respective tenants, and other detail. But the results in ten years, viz. from 1832 to 1842, were as follows:—

	£.	s.	d.
The cost to the proprietor for underdraining and fencing	1958	0	0
For building and repairs	2417	0	0
Total .	4375	0	0
Timber sold in aid	1488	0	0
Actual cost . . .	£2887	0	0
The 2714 acres then let for	2863	15	0
The former ill-paid rents were	2079	16	8
Advance	£783	18	4

This was nearly 27½ per cent. on the outlay, or above £20,000. fee-simple value, created at an expense of less than £3000. in ten years, with similar moral and monetary benefits to the tenants and to the labourers as mentioned in the larger instance aforegoing. Several other estates under the author's care have received similar benefits, by similar means, during the last thirty years.

In the second volume of the Journal of the Royal Agricultural Society, 1841, is a very interesting paper on the benefits of underdraining in Cheshire. Thirteen instances of various qualities and quantities of land are given; and, in two instances, lands worth but

8*s*. per acre were brought to be worth 22*s*. and 26*s*. per acre. Four instances of lands worth 10*s*. per acre were made worth 27*s*., 30*s*., and 35*s*. per acre respectively. The least instance of increased value was from 15*s*. to 30*s*. per acre, and the greatest was from 16*s*. to 40*s*. per acre. On the whole, 467A. 0R. 9P. were underdrained, at a cost of £1588. 17*s*. 4*d*., or about 64*s*. 7*d*. per acre. The result being an increased rental value of £689. 13*s*. 1*d*. upon a former value of £254. 10*s*. 9*d*.; being nearly 30 per cent. upon the expenditure, and an increase of above 60 per cent. on the rental value. Surely more need not be said on the general benefits of underdraining.

We will now extract from the Evidence before the Lords' Committee of 1845, not only their general opinions on the benefits of underdraining, but also the actual benefits experienced by several witnesses as to increase on their crops of corn and other produce.

No. 1 conceives that if rents have a tendency to fall, the drainage of an estate that is waterlogged may keep them up, and even increase them, as drainage diminishes the expenses of a tenant, and increases his produce.

No. 2 states that his tenants gladly paid 7 per cent. on the cost of draining, and did the carriage.

No. 3 could only grow 3 sacks of wheat per acre before draining; afterwards grew 8 sacks per acre on average, and on one field 12 sacks per acre. The whole produce of the farm has more than trebled. Since the draining, "it has grown on an average from 7 to 8 sacks, taking bad years and good years; and turnips, swedes, and mangel-wurzel, and all such things, have been grown on it in great perfection, which could not be done before, from the tenacity and wetness of the soil."

No. 4 states, that since he underdrained his land, his crops have so improved that, though he did it all at his own expense as a tenant, he has been well remunerated. Employs more labourers in consequence, and grows turnips which he could not before. The produce is increased 10 or 15 per cent. Grows full 4 bushels per acre more of wheat. Grows barley where he could not before draining. The crops are more easily harvested. The land is more easily cleaned, and does not burn so much. Thinks clover roots will go down 3 feet in drained land.

No. 5. His land is greatly improved by draining. Is more productive, and less expensive. Can grow turnips where he before could not, though on stiff land. Keeps more stock. Grows 2 sacks per acre more wheat; perhaps 3 sacks.

No. 6. From a very poor field of "conglomerate gravel," called "Starve Acre," had 4½ quarters of wheat per acre, in consequence of draining and subsoiling. Deems deep draining an immense improvement. It forwards vegetation in the spring two or three weeks, viz. one-fourteenth to one-twentieth of the whole period of the growth of plants. Finds this exemplified in rye for spring feed, which is two or three weeks more forward in the drained parts than the rest of the field. It also forwards the seasons for tillage, enables the farmer to get a better tilth, and to prepare for crops at much less expense. The wear and tear of implements are less; the land is much more healthy for stock; the plants are much less liable to hurt by frost; the soil less infected by wireworms, slugs, &c.; the manure is more effective; the grass burns less in summer, or bears drought better. Labour is increased profitably by draining, because more corn and more cattle crops are grown, and more stock kept. Without draining, his land would not be worth one farthing. Now sows turnips amongst his beans, feeds them off with sheep, and then takes wheat. Grass land is not so much benefited by draining as arable; but arable may grow 2 or 3 quarters of wheat per acre more.

No. 7 considers draining to improve the land from 20 to about 300 per cent. with good cultivation afterwards. It enables land to grow crops not otherwise admissible, and renders the soil more fertile and less expensive. Has grown 40 to 43 bushels of wheat per acre on land which his neighbours thought incapable of yielding more than 10 bushels per acre, without resting nine or ten years. Drained lands are safe for sheep, which rotted them before. Would with pleasure give 20 per cent. more rent to have land drained than work it undrained.

No. 10. Mr. SMITH of Deanston. "I have no hesitation in saying, that with the aid of thorough draining, and a better system of cultivation generally, the produce of Ireland might be doubled, without going to the waste lands." It is decidedly the first improvement he would recommend, and "considers almost all the operations of agriculture in some degree thrown away until the foundation of thorough draining has been laid." On the stiff heavy Carse lands of Scotland they grow turnips and potatoes, which could not be done until thorough drained. It saves the farmer much expense, besides much time. He can get on his land at times when he otherwise could not. The harvest is earlier. Crops are less liable to be frosted. The seed time is accelerated two or three weeks.

No. 11 is draining grass land now not worth 5*s.* per acre, and in twelve months thinks he could let it for 30*s.* per acre. The improvement of draining in general adds 5 per cent. to rental value. Has a great deal of old pasture which would be worth 15 to 20 per cent. more rent if drained and broken up. Considers that a farmer can lay out no money more advantageously than in permanent draining, where the landlord will assist him; but not otherwise prudent. Draining increases the produce of the soil; enables a man to grow turnips, to get upon land when he otherwise could not; and it diminishes generally his expenses. Considers it the duty of the landlord to find the tiles, and the tenant the labour.

No. 12 considers draining very conducive to the health of any neighbourhood. Wetness of soil induces typhus and other fevers. The benefit is great, both to landlord and tenant. Gladly pays himself 40*s*. a year more rent for a cost of £28. to his landlord. Is sure a landlord would readily get from any good tenant 5 per cent. on any outlay in draining.

No. 15 finds that turnips can be eaten off with sheep on drained land, where they could not be grown before. Deems that any wet spot on a farm, being drained, is worth double the rent it was before; but as all the farm is not so wet, considers 25 per cent. a fair increase of rent on a well-drained and otherwise improved farm.

No. 17. The EARL OF DUCIE. Has drained land taken from tenant, for which he allows 20*s*. per acre, and it is now worth fully 40*s*. per acre. In a bad year for roots, had 16 to 20 tons of swedes per acre on it, and it has averaged 5 quarters of wheat per acre. It was grass land drained and broken up. Decidedly agrees in the opinion of greatly-increased produce by draining.

Sir C. M. BURRELL, Bart., another eminent witness, says, "Every man of common sense, that sees anything and knows anything of country affairs in wet districts, cannot fail to acknowledge the great advantages of draining. I am satisfied that the corn grown in the country may be increased three-eighths by good drainage; and that on stiff heavy soils, where I used to grow 5 sacks of wheat an acre, in the clay districts of the Weald of Sussex, I have been growing, according to the nature of the land, from 7 to 8, and, in a few instances, 9 sacks an acre. In one case, I believe, there was a field which produced a full load of 10 sacks."

These testimonies as to the benefits to be derived from judicious underdraining admit of corroboration by the general result observable on every distinct parish or estate where it is practised, or where the land is by nature sound and dry, without being poor and arid; for there it cannot fail to strike the observer of such things that the farmer and tenantry are thriving: whereas in any district wherein the land is suffered to continue wet and cold, or in that state in Essex called "water slain," a scanty poverty is generally found to prevail amongst the tenants and the labourers, only prevented from more or less extending to the landlord himself by the paucity of his revenue in one place being compensated by his possessions in other places.

The benefits of underdraining to a tenant-farmer admit of easy calculation. Thus, if we take any given quantity of land required to be drained by the tenant, at 4 feet deep, and 2 rods apart; landlord finding tiles; he, the tenant, will have to expend about 30*s.* per acre, or say, at the outside, £2. per acre. Now let us suppose the land to be under a four-course system of cropping, and that before draining the crops are moderate, but afterwards increase in something like the ratio given by the witnesses aforegoing, we shall have the following results:—

UNDRAINED, *i. e.* WET.		£.	*s.*	*d.*	£.	*s.*	*d.*
1st Year.	½ Turnips, worth . .	2	0	0			
"	½ Fallow	nil.			1	0	0
2nd Year.	½ Barley, 4 qrs. @ 30*s.* per qr.	6	0	0			
"	½ Oats, 5 qrs. @ 20*s.* per qr.	5	0	0	5	10	0
3rd Year.	½ Clover, ¾ load @ £3. per load	2	5	0			
"	" After feed . .	0	10	0			
"	½ Beans, 2½ qrs. @ 30*s.* per qr.	3	15	0	3	5	0
4th Year.	Wheat, 2½ qrs. @ 50*s.* per qr. . . .				6	5	0
	Four years produce. .				4)16	0	0
	Average yearly produce . .				£4	0	0

UNDERDRAINED, *i.e.* DRY.	*£.*	*s.*	*d.*	*£.*	*s.*	*d.*
1st Year. Turnips				2	0	0
2nd Year. Barley, 5 qrs. @ 30*s.* per qr. . . .				7	10	0
3rd Year. ½ Clover, 1½ loads @ £3. per load	4	10	0			
" " After feed . .	1	0	0			
" ½ Beans, 3½ qrs. @ 30*s.* per qr.	5	5	0			
				5	7	6
4th Year. Wheat, 3½ qrs @ 50*s.* per qr. . . .				8	15	0
Four years produce. .				4)23	12	6
Average yearly produce .				£5	18	1

Here we have £16. in four years in one case, and above £23. in the other; making a return of above £7. for the £2. expended, besides all those collateral advantages enumerated aforegoing by experienced persons. Taking the average yearly monetary increase from £4. per annum average yearly produce to £5. 18*s.*, the difference 38*s.* gives an interest of nearly 100 per cent. per annum on the sum expended, agreeing with what was said by witness No. 7, that the benefits of draining varied from 20 to 300 per cent., meaning, as we understand it, an increased produce of from one-fifth more to three times as much as before draining; and the evidence of increase given aforegoing bears out such opinion.

Such a great return is open to the inquiry, Why do not all tenants underdrain, as a matter of course, at their own expense? and, Why do they require the landlord to assist them even with tiles? We answer, Because all tenants are not sensible of probable advantages to this extent. Because they are seldom in the habit of making these kinds of calculations. Because they have seldom more than sufficient capital to enable them to carry on their farms at the least possible outlay. Because they are often fearful of their rents being raised, should they effect any improvements. Because the benefits of underdraining are not always so great as here set down, though sometimes greater. Because such a degree of benefit presupposes good cultivation, whereas farmers' habits are often fixed. Because they know of none but their usual and long-accustomed ways, and deem all others dangerous innovations. Because, in times past, an advance in their tithe-composition might follow an increase of produce, or because their rates and taxes might be raised. Because they are unwilling to employ more labour in the parish, in proportion to their holdings, than their neighbours. Because they have a repugnance to expend large sums for the improvement of an estate, unless the landlord shares in the expense. In fine, because it has only recently become universally known and felt in the agricultural world (except Essex, which of necessity has underdrained, at 10 to 15 feet apart, and 20 to 30 inches deep, for 200 years at least), that to keep out the glut of foreign produce, we must supply the population at something like the same rate at which that produce can be imported; that to do this, we must avail ourselves of all the aids which scientific and practical modes of management can afford; that amongst these, judicious and economical underdraining stands pre-eminent—consequently, that its adoption is imperative; that both landlord and tenant must join in its accomplishment; that the Royal Agricultural Society of England has collected, and is collecting, the most useful intelligence towards the promotion of this improvement generally, and on all soils; that it behoves farmers of every class to adopt the suggestions so carefully studied and proved by practice; and that such suggestions being adopted, and such practices followed, there can be no doubt of the ability of the British farmer to beat all the world in the competition for cheap food, in the same ratio as the British manufacturer has beaten the world in cheap fabrics, and the British mariner in cheap and successful navigation.

On the whole, to sum up the benefits of underdraining, it clearly appears,—

1. That it answers well to a tenant.
2. That there are several collateral advantages of some importance.
3. That, on the large scale, it admirably answers the purpose of the landlord.
4. That it promotes the interest of the labourer.
5. That it benefits the community, by producing abundance of cheap food.
6. That it promotes health in any district where it becomes universal.
7. That, by enabling the British farmer to compete with the foreigner, it sustains the supremacy of British agriculture.

VIII.

ON THE BEST MODE OF UNDERDRAINING AN ESTATE.

THE necessity and the advantages of underdraining being established, it becomes a matter of very great importance to a landlord to ascertain the best means of carrying out so essential an improvement over that territory which Providence has confided to him as proprietor and patron, with due attention to his own immediate means and interests; to the well doing of those who are more immediately dependent on him, viz. his tenants and their labourers; and to the interests of society. It may, however, be sufficient to consider principally the interests and convenience of the landlord, since that being accommodated the others will follow, if not as of course, at least so far as the circumstances of the individual case will allow.

Formerly it was the prevailing creed in the management of estates, that farmers were an encroaching set of people; that nothing whatever should be yielded to them; that to squeeze them was the only good policy; and that the improvement of estates was a fallacy to be avoided. Of late years, however, a different line of policy has been seen and acted on.

Various modes have been adopted by landlords with a view to improve their estates, by means of draining &c., and amongst them may be reckoned,—

1st. To drain under recent or incipient Acts, by funds borrowed of Government, and primarily charged on entailed estates.

2nd. To drain by means of their own funds and agency, the tenant paying a per centage on the expense, in addition to his rent.

3rd. To drain by the mutual efforts of landlord and tenant, as previously arranged between them.

Firstly. The means of draining and other improvements on lands have been lately sought to be provided, under powers afforded by the Legislature, for the tenant in tail to borrow money for that purpose of Government or otherwise, and charge the amount on the estate, repaying a certain portion of the principal, together with the interest, yearly, in periods varying from ten or twelve to twenty or thirty years.

When, however, it is considered how many restrictions and formalities must necessarily accompany such powers; how many hands such forms must go through; how much must necessarily and inevitably be their cost; how vaguely, after all, must be described the anticipation of what is intended to be done; how much what is actually done will be seen to differ from any previous description of it; how dangerous will be the deposit of a sum of money for a purpose which must take time to carry out; how much the views of parties are apt to alter during the progress of such works; how difficult for the tenant in tail to judge between conflicting opinions as to the best modes of draining, yet how necessary for him to inquire and judge before laying out money under a species of trust; how jealous will be the remainder-man of the misapplication of funds, great part of which he may have to repay; how equitable that he should be a party to the application of those funds, yet how difficult and expensive to make him so; how apt he will be to doubt as to the efficacy, the sufficiency, and, above all, the permanency of such drains, and their actual benefit to him; how productive of misunderstanding and litigation where he is not such party; how contradictory the evidence which would be adduced in such litigation; how jealous, also, will be the mortgagee of having a prior charge taking precedency of his own; how proper to make *him* also a party; how difficult to convince him of the propriety of draining, and of overcoming his conviction that all will end in still further draining the mortgager's pocket. When, I say, all these points of difficulty are considered, the eligibility of such a mode of raising the means of draining will appear in a very questionable shape; and accordingly in practice there were but eleven applications under the Act 3 and 4 Victoria, cap. 55, enabling parties with limited estates to charge the inheritance under certain regulations with money expended upon permanent improvement by drainage.

It does not, therefore, seem probable that much underdraining of lands, as a farming operation, will be accomplished under any legislative enactment. Nor does it seem either feasible in itself, or in anywise creditable to the landed interest, that they should endeavour to shift from their own shoulders to those of their posterity any portion of the expense of an operation which is little beyond what comes under the category of good farming, or at least good management, and which so amply repays a landlord for promoting, and a tenant for executing. And when we also consider that a glut of produce would follow upon such a general impulse towards draining as powers to borrow for it would give, if such powers were as available as they are not, the conclusion is inevitable, that landlords had better be left to devote what funds they can or are disposed to spare towards that object. Let us now therefore consider,—

Secondly. The mode of effecting underdrainage at the landlord's expense, and under his sole direction, the tenant paying a per centage on the cost as additional rent. Now there is something at first sight plausibly judicious in the proposition of this mode of proceeding, inasmuch as it seems to place the proper performance of the work of draining entirely in the hands and in the power of the landlord; and this eligibility seems peculiarly to belong to the present period, inasmuch as men of talents and science are to be found more readily than at any former period, who, in the capacity of professional drainers, undertake the superintendence of such works to any extent. But when it is considered that underdraining can only go on during one season of the year; that it requires the constant co-operation of several parties; that much foresight and previous arrangement are required to dig the earth in winter, to make the tiles in summer, to collect the fuel to burn them, and to carry them to the fields to be drained; that all this can only be done on or near the spot; that the occupier of the lands must be a very active party to these operations; that only particular portions of his land can be in a state for underdraining in any one season; that the landlord's drainers may wish to drain tenants' clover lands, whilst he wishes them to drain his fallows; that draining carried on independent of the tenant may often prevent his cropping the land in due season; that it is very distasteful to the feelings of a tenant to have other than his own people working upon farming operations upon his land, and entirely out of his control, though he has an interest in the result; that the professional drainers would employ strangers as labourers in preference to natives; that the landlord, having to pay so many agents and overlookers under them, must be at a far greater expense for draining than the tenant on the spot would be likely to incur; that if the draining is to go on simultaneously in many parts of an estate, many superintendents must be employed; that if confined to one part, the draining must go on very slowly; that so large a sum of money as would be required for the landlord to do all the draining might be very inconvenient to most of them; that professional drainers are apt to incur expenses beyond what are needful, in order to secure their credit and reputation, by over anxiety doubly to effect a cure; that a tenant may not always approve either of the mode in which, or the degree of economy with which the drains are executed; that he would justly feel a hardship in paying interest on work which he disapproved; that interest on improvements added to a tenant's rent advances it beyond what he may willingly continue to pay,—thus, say 300 acres are to be drained with tiles at £6. per acre, the price stated by witness No. 10, and tenant pays 7 per cent., the increased rent is £126, or with agency fees, &c., full 50 per cent. on a former rent, say of 20*s*. per acre, all rateable and taxable as rent; that there would be great danger of tenants endeavouring to wriggle out of such large additions to their rents, first by pleading the hardship of the case, damage in execution of drains, loss of crops by delay, and so forth, and finally treating the advance as a debt standing on a very different legal footing from the actual rent, and placing obstacles in the way of its recovery; that the guarding against such dangers would involve expensive legal processes; that, after all, unless the tenant employed good cultivation subsequent to draining, he might be wholly unable to pay the advance; that in such cases the burthen is much more thought of than the benefit; that the benefit is altogether lost unless followed up with good cultivation; that a tenant submitting to have his land drained for him would be an indication of poverty of mind as well as means, incompatible with improved cultivation. When, we submit, all these points are duly weighed, it does appear to us that for a landlord to undertake to drain his estate at his own expense is so fraught with difficulties, and dangers of excess in expense, failures in execution, and uncertainty in returns, that it is not advisable for any landlord to extend that mode of draining an estate beyond the lands in his own immediate occupation. Another mode is, however, open to him, viz.,—

Thirdly. To accomplish the underdraining of his estate through the medium of his tenants, allowing them a sufficiency of draining tiles or other materials, and seeing that they put them in properly, and perform cartage at their own expense. It was by this mode that the very considerable effects were produced as stated aforegoing in the first section of this discourse: so that in preferring it to either of the above-mentioned plans, I do so upon long and extensive experience; and in recommending it I consider that the converse of almost all the objections to the other modes will hold good, and the following points of importance are secured, viz.,—

1. You make each of your tenants an overseer, agent, or superintendent of the men employed, and escape the expense of them.

2. As the tenants have an immediate interest in the effects of the work being well done, they will be more vigilant than professional drainers, and their overlookers and foremen.

3. The interest of the tenant, being immediate, is greater than the reversionary interest of the landlord; therefore his vigilance is likely to be

effectual, and its exercise may be relied on to the best of his ability.

4. The superintendents thus become numerous and effective over a large space, without expense.

5. Draining may thus go on simultaneously over many parts of an estate, and its benefits be soon felt.

6. The lands, only coming properly in course for draining, will be commenced at the proper time, and in proper order.

7. The tenant will take care to have the work done in due season.

8. He will know the best labourers to employ, and those most useful to the parish to be employed, whilst they get expert at that kind of work.

9. It being his own money that he pays in labour, he will not be likely to lay in more tiles than are necessary to drain the land.

10. A tenant that has bestowed great pains and labour, and expended considerable sums in draining his land, will be anxious to cultivate in the best manner, and to improve his farm in other respects.

11. The tenant, as he increases in means, and becomes prosperous by the effect of his own work

in draining, assisted by the landlord, will become attached to his occupation, anxious to continue in it, and in due time will be willing to give its utmost value as rent rather than leave the farm. And this moral effect arising from the tenants being made instrumental in effectuating the underdraining and other improvements of an estate is of much more importance than is generally imagined; for whilst the landlord's assistance in finding tiles, &c., makes him a partner with the tenant in this great work, it gives him a reversionary interest in it, and an equitable and moral right to avail himself of its benefits, after a period, allowing the tenant to be amply repaid for his outlay and exertions. The tenant's feelings in this kind of co-operation with his landlord are very different from those which arise from his draining the lands with tiles at his own expense, which he is apt to think gives him a perpetual interest in them; and very different from his paying interest on the landlord's outlay, which he will always deem profuse, and therefore oppressive. In fine, a tenant is identified with the interests of the estate and of the landlord by the kind of cordial co-operation here advocated.

12. It was said by one of the witnesses before the Committee quoted aforegoing, viz. Mr. Hewett Davis, "Nineteen-twentieths of the drainage done throughout the kingdom is done very badly. It is generally left to the tenants, and in that case is almost sure to be badly done, for they can have no previous experience. They do not read, and have no idea of what improvement is going on." But I apprehend that an inferior class of tenantry is here meant,—tenants of "adhesive clay land, which is almost worthless without being drained;" small farmers, and those not yet enlightened as to the benefits or the modes of draining. When, however, we see in the lists of the members of the Royal Agricultural Society, perhaps 5000 tenant-farmers out of the 6000 subscribers, and that each of those are furnished with and undoubtedly read their Journal, we cannot doubt that every part of the country has a sprinkling of enlightened farmers fully equal to the duty of superintending labour performed for their own benefit. Now there is not under the sun a more imitative creature than the farmer; and it cannot be supposed, that a good example being set in so important a matter, that example will not be followed, even by the smallest occupier.

13. Besides it is the business of the managers of every estate to instruct the tenantry in the proper use of tiles allowed by the landlord, by distributing such treatises as this, and by verbal explanations arising out of inspections of what is doing on the estate.

14. This division of expense between landlord and tenant is fair, and it greatly relieves a landlord, who generally finds the supplying of tiles a sufficient burthen; whilst the tenant is repaid by one or two crops, and can go to work again with increased means by increase of produce.

15. The agent can also by this mode regulate and limit the quantity of draining on the estate for which he finds tiles. He can proportion it to circumstances, and to the means or inclination of of the landlord, as well as to the wants of the tenants.

In Appendix C we have given an extract from some regulations as to delivery of tiles from the kiln to the tenantry of a large estate where 350,000 have been delivered in one year, and several millions in the whole. On that estate the mode herein recommended succeeded admirably, and its results have been herein recorded, viz. enriching first the tenant, and then the landlord. It must, however, be remarked that these results were very gradually brought about; that they took many years of steady perseverance to accomplish; that they were not the result of a grand and mighty effort suddenly exerted and then falling off; but of quietly surmounting difficulties, of bearing with some failures, of combatting many ignorances and obstinacies, of curing many bad habits, and correcting many errors, until, finally, something approaching to perfect draining was established, and its benefits extended to the concomitants of good cultivation, good buildings, good fences, and a good, respectable, and thriving tenantry.

APPENDIX.

APPENDIX A.

COPY OF INSTRUCTIONS ON DRAINAGE ISSUED TO TENANTRY

OF

STOW-HALL ESTATE.

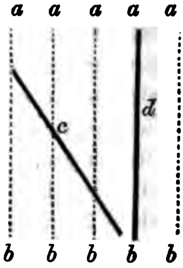
MR. WIGGINS requests the tenants' attention to the following practical observations on Underdraining, which he deems it his duty to submit, in consequence of the prevalence of what he thinks erroneous notions on the subject.

1. That deep drains relieve a much greater surface of land from superfluous water than shallow ones, as is observed by experience, and demonstrable by theory. This effect was very apparent, to the most casual observer, in the wet summer of 1816, when the barley crops might be distinctly seen *good* over and within 10 yards of a 3-feet drain, and *bad* in the centre of the space between two drains of 30 yards apart, the space of bad crop being narrower or wider according to the depth of the drain; therefore deep draining requires fewer tiles and labour than shallow on a given number of acres.

2. That deep drains have the great advantage over

shallow ones of being beyond the reach of moles, roots, and tread of cattle, heavy carriages, &c.

3. That in setting out drains, sufficient care is not taken to place them slanting the fall, so that they may *catch* and *draw* as well as carry. The importance of this does not seem always well understood; although it is clear, that if a drain be cut right up and down a hill, as practised in some districts, it will carry little, if any, more water than what may run in at top, or at the immediate sides of it; but if cut diagonally across the hill, it will draw or catch the water along its whole course: thus, if the lines *a*, *a*, *a*, and *b*, *b*, *b*, in the figure in the margin, represent the fall of the water from the top to the bottom of the hill or slope, whether that slope deviates little or much from the flat surface, it is evident that the diagonal drain *c* will catch or intercept much more water in its passage down the slope, as well as have a greater tendency to aid its efforts to sink into the earth, than the drain *d*.



4. If we consider the above-mentioned double-motion of the water escaping from the surface and vegetative portion of the earth, the importance of depth in the drain *c* will be the more striking, since it is evident that the deeper it is, and the greater the inclination of the surface, the greater will be the influence of the drain *c*, or the further distance from itself it will draw the water from the land; consequently, the fewer drains will be required on a given surface.

5. It must, however, be considered that a deep drain on stiff soil will take a longer time to relieve the land than a shallow one; but we are apt to be impatient of seeing water on the surface at any time, forgetting that draining is not merely to please the eye, but to relieve vegetation of the chill of stagnant and superfluous water, which lies not altogether on the surface, but at 18 or 20 inches below it, forming on flat lands a sheet of water checking vegetation till so late in spring or summer that the time for cropping is passed. Now, as water may remain some hours on the surface without injuring vegetation (perhaps twenty-four hours on arable land, and more on grass land), all we want is to get it off *in good time*, which a drain of 30 inches depth will always do in a stiff soil, and 36 inches in a loose soil.

6. The appearance of water standing in pools, just over or by the side of drains, is no evidence of the drains being too deep to work in *good time*, as is often thought; such appearances often arising from a different texture of the soil at that spot, by reason of working, treading, or even its natural state.

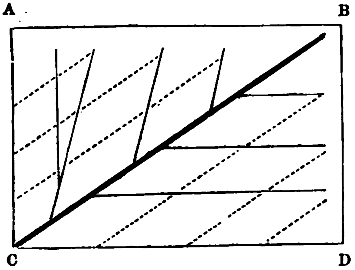
7. That, in order to relieve the land in good time, a drain must be of greater depth than the depth to be relieved; thus, if a drain is only 18 or 20 inches deep, it will scarcely draw off the water to *that depth* in good time, or at a greater distance than 5 yards in stiff soils. Now a sheet of water remaining in the land, at 18 or 20 inches deep, would still check and chill vegetation, though perhaps not near so much as if no draining had taken place; whereas if one-third the numb[illegible]

of drains were made 30 or 36 inches deep, they would drain 10 to 15 yards, and reduce the sheet of water in *good time* to 24 or 30 inches deep at least, *i. e.* out of danger to vegetation.

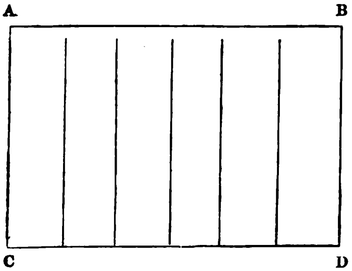
8. That it is not the object and end of tile or other underdraining to supersede the necessity of water furrowing to carry off surface water only, for that would be to save a few shillings per acre at the expense of some pounds; but, as before stated, underdraining is to reduce the depth of that sheet of water which is held up by a retentive subsoil, and to carry off the springs, &c., which are thereby occasioned at particular spots.

9. It is an error to suppose, as many do, that stiff soils are impervious to the water, since the fact is that they abound with fissures and apertures in all directions, and also with minute tubes or pipes occasioned by the contraction of the soil when dry, and expansion when wet, the putrefaction and decay of roots, worms, and various insects, and by other natural causes; and these apertures, though imperceptible to the naked eye, are fully effectual to enable the water to percolate and find its way through these soils down to the escape provided for it by means of drains, &c., in *good time* for vegetation.

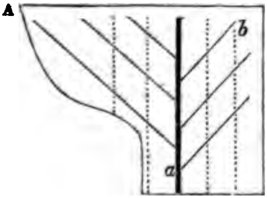
10. The herring-bone fashion of draining, as practised in Essex and adjoining counties, does not appear to be well understood or well practised in other districts, though particularly applicable to flat surfaces, and admitting of a great economy in tiles by means of



wings; thus, A, B, C, D being a field to be drained, and the outfall at C, with the general fall of the land in the direction of the dotted lines, it is clear that a tiled main drain C, B would carry all the wings which may be filled with wood and straw, and when decayed, say in twelve or fourteen years, new ones may be cut, either between them or in such directions as will bleed the old drains. In Essex, a wood and straw main drain is reckoned to carry well 100 rods of wings, and a tiled main drain will undoubtedly carry more than double that quantity. Supposing, therefore, the above field to be 12 acres, and the tiled main drain to do nothing but carry the wings, and those to be 10 yards asunder, one tiled main drain will be sufficient, and this will take about 900 tiles of 12 inches each; whereas if the same field was drained with tiles only, in the manner usually practised, and shown in the margin, the dyke C, D being deepened for a main drain to the outfall C, it would take above 15,500 tiles at 11 yards drain from drain, a difference

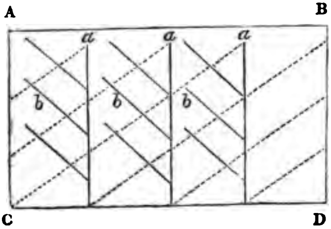


which seems to have been overlooked, and to which Mr. W. begs to call the tenants' serious attention. The herring-bone fashion is also particularly applicable to wet spots in fields, as at A. *a* is the main drain, and *b* the wings; suppose this to be 3 acres, or about 40 rods long, and 12 wide. To drain this with tile mains and wood wings at 10 yards would take 600 tiles; but in the common way, as in dotted lines, it would take 3600 tiles.



11. Some persons object to the herring bone, that it brings the drains too close to each other at the point of contact, particularly if the angle there be acute, and therefore makes double work; but this is evidently a fallacy, because, however acute the angle may be, the wing takes no more cutting than if it made a right angle with the main.

12. In cases where drains were cut some years ago at 20 or 30 yards apart, as a foundation for more complete drainage, these wings will be extremely applicable, if cut diagonally between drain and drain, as in margin, A, B, C, D, being the field, C the outfall, *a* the old drains, *b* the proposed wings, the dotted lines showing the general



fall. Now if the wings were cut 20 yards apart, and the ends within 10 yards of the main drain, this field would in fact be drained within 10 yards, and much more effectually than if another tiled drain were cut between the two drains now at 30 yards apart, and the same number of tiles required, viz. about 400 per acre.

13. It is recommended to have a tile or two fitted to the wing at the point of contact with the main. If the wings were much adopted, angle or branching tiles may be made on purpose.

14. In cutting wing drains, experience shows that they must not have too quick a draught; that they must be as narrow as possible at bottom, and very well cleaned out, which in Essex they do with a fluted hoe, not common in other parts. And in filling them it is found that the best wood is blackthorn or elm, and the worst (nearly) young whitethorn; that the wood must be well covered with straw, sedge, or turf sods, and that the deeper they are (*i. e.* the nearer 3 feet) the more effectual. As to the wood, its duration depends as much on the mode of laying it in as on the sort: it should be laid with the spray of one branch over the butt of another, the butt always at the bottom; the less wood used the better. In Essex, it takes half a load of wood to do 120 rods, and one load of straw.

15. But the comparative expense of labour to the tenant will naturally be considered; let us see, therefore, how this matter stands. If a score rods of tile drains 3 feet deep cost 10*s.* to cut, cart, and fill, the like quantity of wing drains will cost only 6*s.* 8*d.* or 7*s.* at most,

reckoning the labour at 4*s*. per score, and the usual quantity of wood and straw at full value; so that the tenant will at least be no loser by economizing the tiles allowed him by his lease, and employing them over the largest surface he can with effect, as now recommended.

16. It must, however, be recollected that only soils firm enough for the drains to stand till filled without the sides falling in, and admitting of a clear and firm narrow channel at bottom, will do for wood and straw drains; all loose soils will require tiles.

17. Quagmires and other boggy spots have almost disappeared on this estate by drainage, under the late leases; but in anything approaching to such, as well as the sandgalls that may occur in ordinary draining, there should be placed a floor or bed of wood for the flat tiles to rest on. Fir, alder, or birch poles, with a saw-cut down the middle, will do well; and these will be supplied from the timber-yard as wanted.

18. In tile drains, nothing is more common than the false economy of omitting the bottom tiles, or otherwise supporting the corners of them by tile shreds, stones, &c., or by making them with wide edges. This is an error fatal to the object of a *permanent drain*, which should be an arch, resting on a flat, well-bedded, continuous pavement of tiles; forming as regular and accurate an inclined plane as the work will allow; the tiles as little broken as may be; and the joints covered as much as possible in laying the arched tiles. Without *all* this care, the tiles will inevitably become displaced; some will turn sideways to the right, some to the left; some

will kick up at one end, some at the other; and some will sink into the softened soil, so that the arch will soon become broken, and the drain stopped and useless: nor is the apparent firmness of the soil sufficient security against this effect.

19. Many think that without holes in the tiles, the water will not get in: but this is a fallacy; for it sinks, or rather is attracted down to the flat tile, and rises and flows off down the inclined plane of the arch.

20. Some deem it necessary to put stones or other loose material above the tiles; but the native earth is preferable; a little of the loose top soil first to cover the tile, and then the subsoil to fill up. Whether that is porous or tenacious is no matter; for the drain does not work perpendicularly, but obliquely *from the bottom to the surface*, and more or less so in proportion to the depth of the drain, the inclination of the surface, and the diagonal direction of the drain, taken conjointly, as hereinbefore shown. Indeed, this fear of stopping a drain by its covering often becomes the cause of tiles being displaced, and the arch broken for want of a solid and equal bearing on them.

21. In many cases the calcareous or marly subsoil dug out of drains is of a quality sufficiently good to "clay" the land. Mr. W. recommends in that case that a large portion of it be spread on the surface, and the sides of the drain sloped in, so that a dip be formed which will carry off the surface water. These artificial "rills," as they are called, are formed in some districts purposely, particularly on flat lands.

22. Mr. W. persuades himself that the tenants will do him the favour to take these as friendly hints, given to impress the more those *vivâ voce* opinions which he has often already urged, although many may not have required them; and should they seem presumptuous, he begs to plead many years of experience and observation on the subject, and a conviction of its great importance, and of the necessity of a minute attention to points apparently trivial, but in reality essential.

30, TAVISTOCK PLACE,
January, 1833.

APPENDIX B.

COPY OF REGULATIONS AS TO ISSUE OF DRAINING TILES, JAN. 1833.

STOW-HALL ESTATE.

Mr. WIGGINS requests the tenants to observe the following Regulations :—

1st. When they send to the kiln for ware, to give strict orders to the men not to load any but the best well-burnt ware, and to send some person with the waggon who can judge of them, and will see to the quality and tale.

2nd. If any bad ware is sent, on no account to use it; but to return it by the next waggon to the kiln, and inform Mr. W. of the number so returned.

3rd. To give the kilnman a receipt for the ware he delivers, load by load, until the order given by Mr. W. is out, as he will only be paid the amount of such orders and receipts.

4th. To take care to have bottom tiles in proportion to the arch tiles for draining; and not to lay any drain without a continued pavement of bottom tiles. The arch tiles should run 12 inches long on the average.

5th. To lay the draining tiles as near 3 feet deep as the outfall will allow, after well scouring out and deepening the ditch.

6th. On lands not before drained, the tile drains not to be laid nearer than 20 yards drain from drain. On lands before drained, one new drain between the two old drains. When the herring-bone fashion is used, the wings to be filled with wood and straw, and with tiles for main drains only.

7th. Tiles (and other kiln-ware) to be carefully unloaded and set up, and hurdles or other fencing set round them till used. Tiles should be carted into the field at once, if possible, and unloaded along the lines of drain to prevent breakage; and the spare tiles, &c., gathered up directly after the work is done.

APPENDIX C.

Extract from a Paper entitled "On the Mode of making and using Tiles for Underdraining, as practised on the Stow-Hall Estate in Norfolk. By JOHN WIGGINS, Esq., F.G.S., &c." Published in the Journal of the Royal Agricultural Society, 1840.

"Lands in some counties are ploughed up high into broad ridges (an ancient method of drainage); the tile drains are then placed in the furrows, and the height of the "lands" or ridges reduced by ploughing down gradually. In such cases there is a very general fear of placing the tiles too deep; and the consequence is that they are often placed so shallow as to be filled by moles or roots, or displaced by tread of horses or cattle in wet times. In furrow-draining stiff lands, the tiles should ultimately lie 30 inches deep, after the lands or ridges have been ploughed down, but not less than 24 inches at first; and in looser and more open soils 30 inches at first, and 36 inches at last, *i. e.* when the ridges are thrown down, these measures are the proper depths on the average, but more in some places; and the nearer they approximate to these depths, the more

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6th. On lands not before drained, the tile drains not to be laid nearer than 20 yards drain from drain. On lands before drained, one new drain between the two old drains. When the herring-bone fashion is used, the wings to be filled with wood and straw, and with tiles for main drains only.

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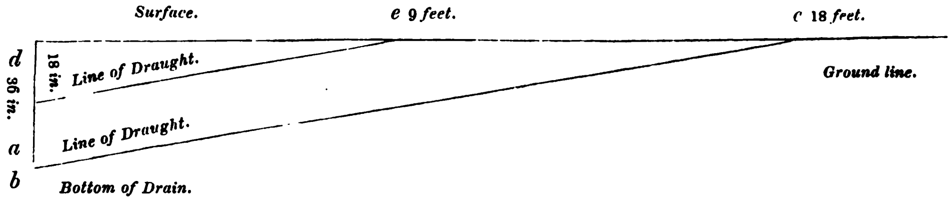
Surface.
e 9 feet.
c 18 feet.
d
36 in.
18 in.
Line of Draught.
Ground line.
a
Line of Draught.
b
Bottom of Drain.

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